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Processing of Energy Resources

ALBERTA RESEARCH COUNCIL

Energy Resources Division
Coal Research Department

Alberta Research Council

The Alberta Research Council is a crown corporation of more than 500 employees promoting responsible economic development in Alberta through a broad range of research in science and technology — Oil Sands, Coal, Industrial & Engineering Research, Natural Resources, and Frontier Sciences thought to be of future economic benefit to the province. The Alberta Research Council is located in Edmonton and has offices in Calgary, Red Deer, Devon, Nisku and Lethbridge.

Since its establishment in 1921, the Alberta Research Council has actively participated in energy resources processing research. Its research in this area is concerned with the development and efficient use of non-renewable energy resources. It offers to its clients,in the public and private sectors of the energy resources industry,professional research and development services and facilities.

The major areas of research and development activities include:

- Hydroprocessing, liquefaction and upgrading
- Pyrolysis, gasification and combustion
- Catalysis research
- Multiple support services

A Complete Research Facility

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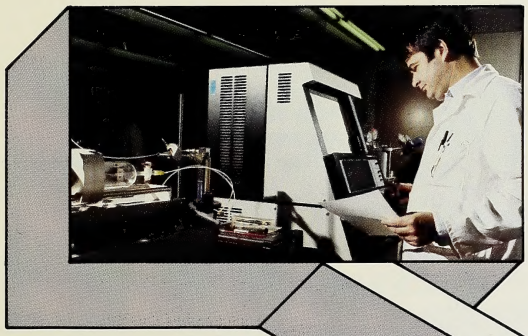
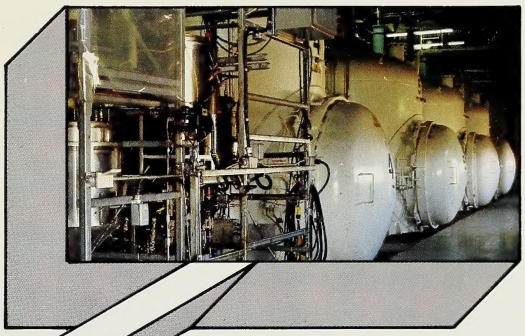
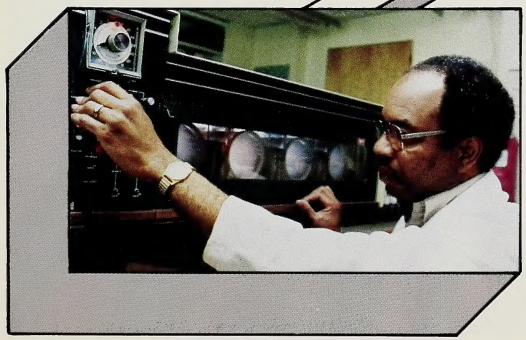
Research facilities range from laboratory scale batch equipment to fully instrumented continuous flow process development units. Researchers recognize the importance of developing mathematical models from experimental data and physical property measurements to aid in optimization and scale-up of process. Support services include economic evaluation, development of data management systems, reactor modeling and fuel rating tests.





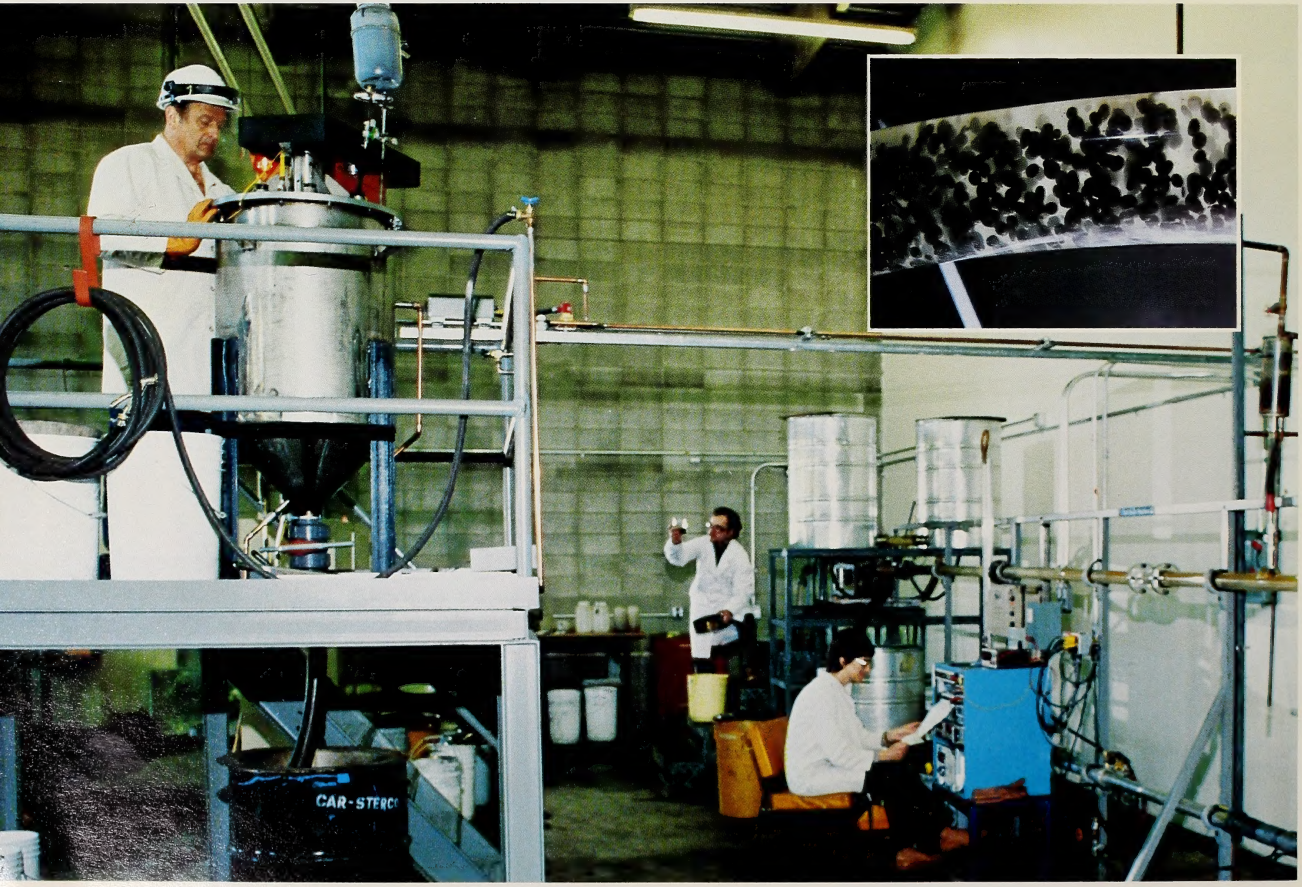


Selective agglomeration of coal

Facilities and expertise have been developed to investigate beneficiation of bituminous and subbituminous coal by selective agglomeration with bitumen or heavy oils. Agglomerates are spherical in shape, mechanically stable and are low in ash and moisture contents relative to the mined coals. Agglomeration technology can eliminate the huge loss of coal fines which occurs in tailings streams of conventional beneficiation plants. Current research is determining optimum conditions for agglomeration using stirred tanks and a pipeline reactor. Other investigations include the recovery of residual oil from the agglomerated product and the rate suitability of the product for long distance transportation and end utilization, e.g. combustion.

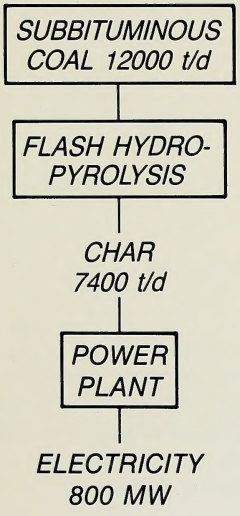
In addition to a stirred tank system (220 L capacity), the Alberta Research Council has a mini-pilot plant facility (10 cm diameter and 22 m long pipeline). The mini-pilot plant is used to investigate the combined agglomeration and transportation of coal in a pipeline. Metallurgical, thermal and subbituminous coals using different liquids including heavy oils and bitumen are being investigated.

Left *Pipeline transportation tests under various conditions result in different sizes of coal agglomerates as well as waste material from simultaneous beneficiation.*
Below *The coal agglomeration test facility.*
Inset *A coal/oil/water slurry travelling through the test pipeline.*



Pyrolysis, gasification and combustion

Pyrolysis combined with power generation



Human resources and facilities at the Alberta Research Council are also dedicated to wide range of problems related to pyrolysis, gasification and combustion.

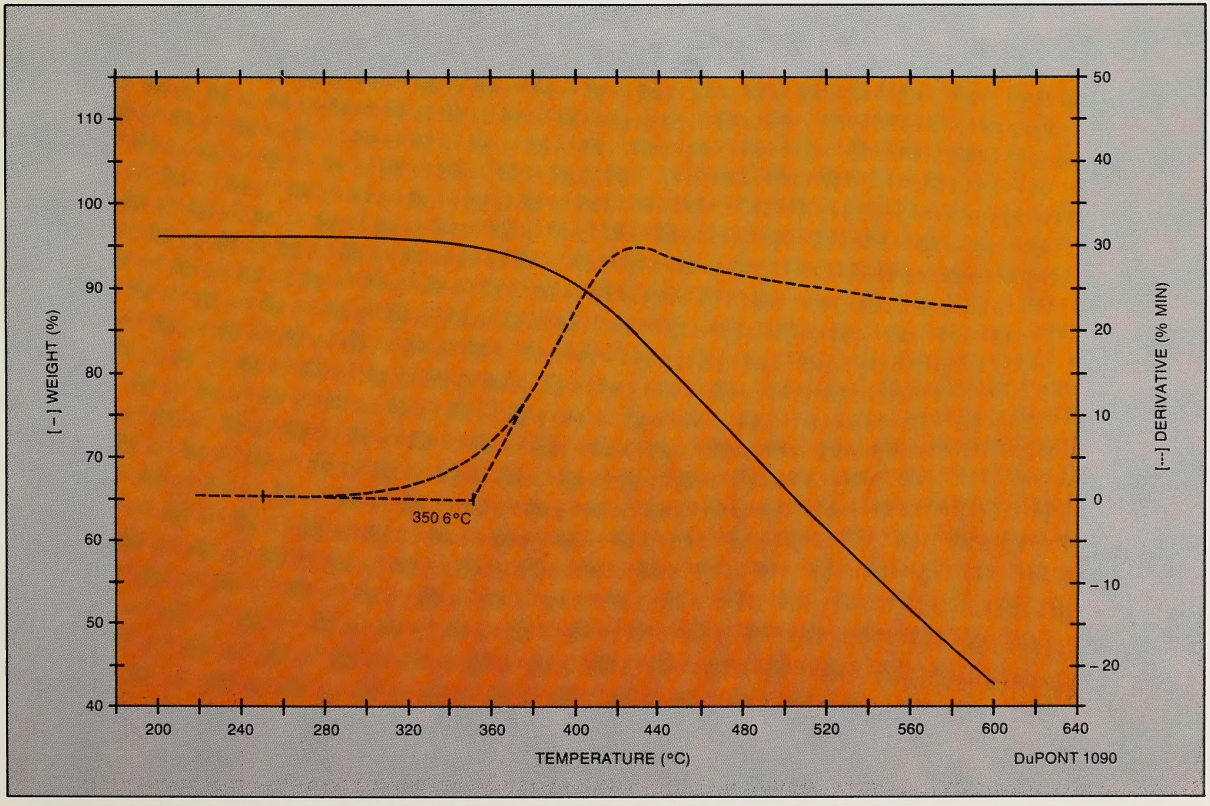
The individual pieces of equipment range from micro-scale atmospheric pressure batch systems to high pressure continuous systems. They have a temperature capability of up to 1600°C and are equipped with on-line instruments and computer data acquisition systems.

The entire facility can be used for processing or co-processing of coal, heavy oil, bitumen and natural gas.

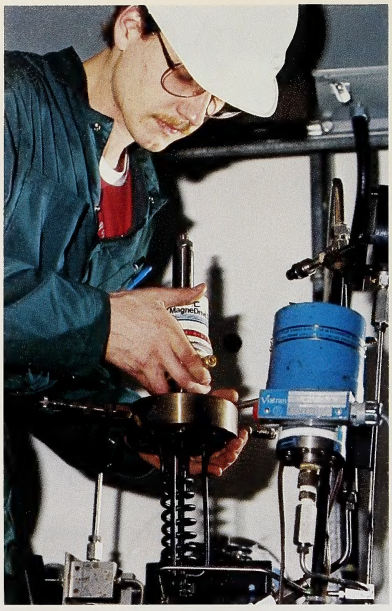
Examples of current research projects include:

- comparative evaluation of Alberta coals in flash pyrolysis using a continuous entrained-flow reactor system;
- optimization of oil yield from flash hydropyrolysis of coal in a high pressure process development unit (PDU);
- combustion and gasification characteristics of coals and chars in batch and continuous flow systems;
- correlation of coal and char reactivity to surface properties;
- evaluation of natural gas and reactive gases as coal pyrolysis media;
- kinetics of rapid devolatilization of coal using an inductively heated bench reactor.

Results of a thermogravimetric test — the fastest technique available for kinetic studies to evaluate the combustability of fuels.



Hydroprocessing, liquefaction and upgrading



The Alberta Research Council can address a broad range of research problems related to hydroliquefaction of coal and upgrading of coal liquids, bitumen and heavy oil, using various sizes of high pressure/temperature equipment.

Hydroprocessing equipment includes tubing bombs, stirred autoclaves, semi-continuous and continuous flow reactor systems, all capable of operating at conditions up to 35 MPa at 500°C. Most of these systems are equipped with on-line analytical and process monitoring instruments, as well as computer control and data acquisition systems.

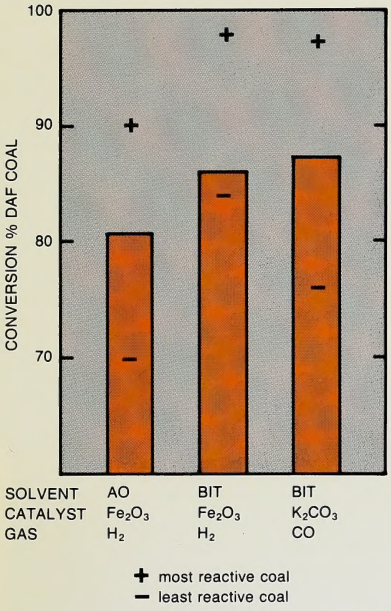
Left *A batch autoclave used to determine parameters in hydroprocessing studies.*
Below *The operation center for the hydroprocessing bench unit.*

Examples of current projects include:

- comparative evaluation of Alberta subbituminous coals in various hydroliquefaction processes using batch and semi-continuous flow systems;
- optimization of selected hydroliquefaction processes in a process development unit (PDU);
- evaluation and development of two- stage coal/bitumen co-processing operation;
- catalytic upgrading of bitumen and coal-derived liquids in continuous flow systems;
- measurement of rheological properties of slurry mixtures at hydroprocessing conditions;
- mathematical modeling and simulation of liquefaction and upgrading processes.

Catalysis research

Optimum coal conversions liquefaction - batch tests



Alberta Research Council professionals have gained international recognition through their contribution in catalysis research.

Examples of recent projects include work in the following areas:

- zeolites;
- Claus reaction;
- Fischer-Tropsch reaction;
- hydrotreating (HDS, HDN, HDO);
- metal clusters;
- catalyst development, characterization and evaluation.

The Alberta Research Council is well equipped with state-of-the-art equipment for measuring surface properties and is capable of delivering professional research and development services in measuring particle size, density, surface area, pore volume and size distribution, and active metal sites.

Speed and accuracy in measuring the surface properties of catalysts are possible with the most advanced equipment available.

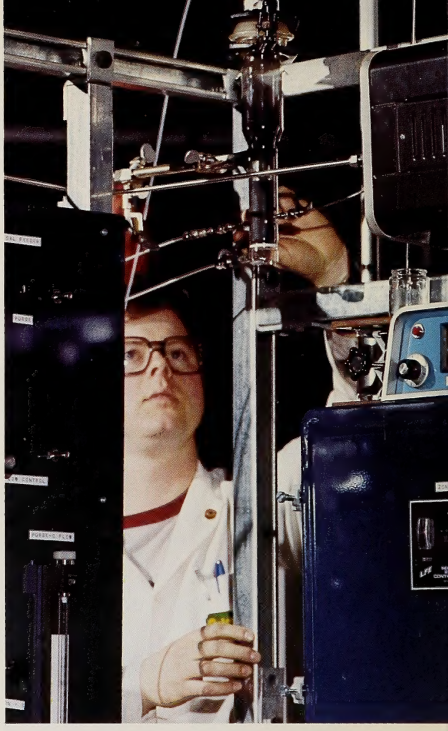
Process related facilities

On-line process instruments and equipment

- gas chromatographs
- ambient gas monitors
- continuous NDIR analyzers
- gamma ray and ultrasonic level detectors
- mass flowmeters
- IR tachometers
- densitometer
- dataloggers and multipoint recorders
- automated data collection micro-computer systems
- gas, liquid and slurry sampling systems

Supporting equipment and facility

- high pressure experiment containment vessels (7 units, 3 m diameter x 4.8 m height; 1 unit, 4.2 m diameter x 9.0 m height)
- high pressure gas compression and distribution system
- PDP 11/24 and VAX 11/78 computer systems
- on-site product work-up and analytical laboratory
- jaw crusher and vibro-separator system (450 kg/hr)
- pulverizer (250 kg/hr)
- semi-continuous wet grinding system (120 L)
- slurry prepration, heating and pumping system
- hot centrifugation system: batch and semi-continuous

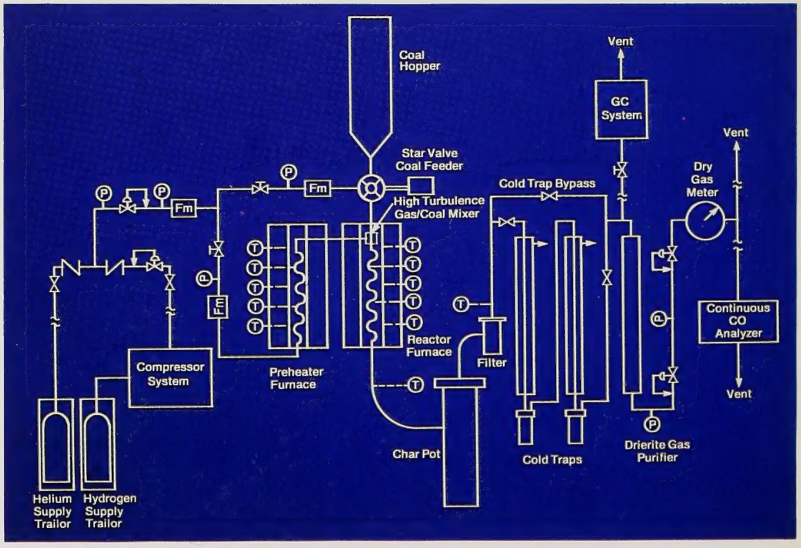


This new system for feeding powder into pyrolysis and combustion test units was designed by the Alberta Research Council, resulting in greater efficiency.

Pyrolysis, gasification, combustion research facilities

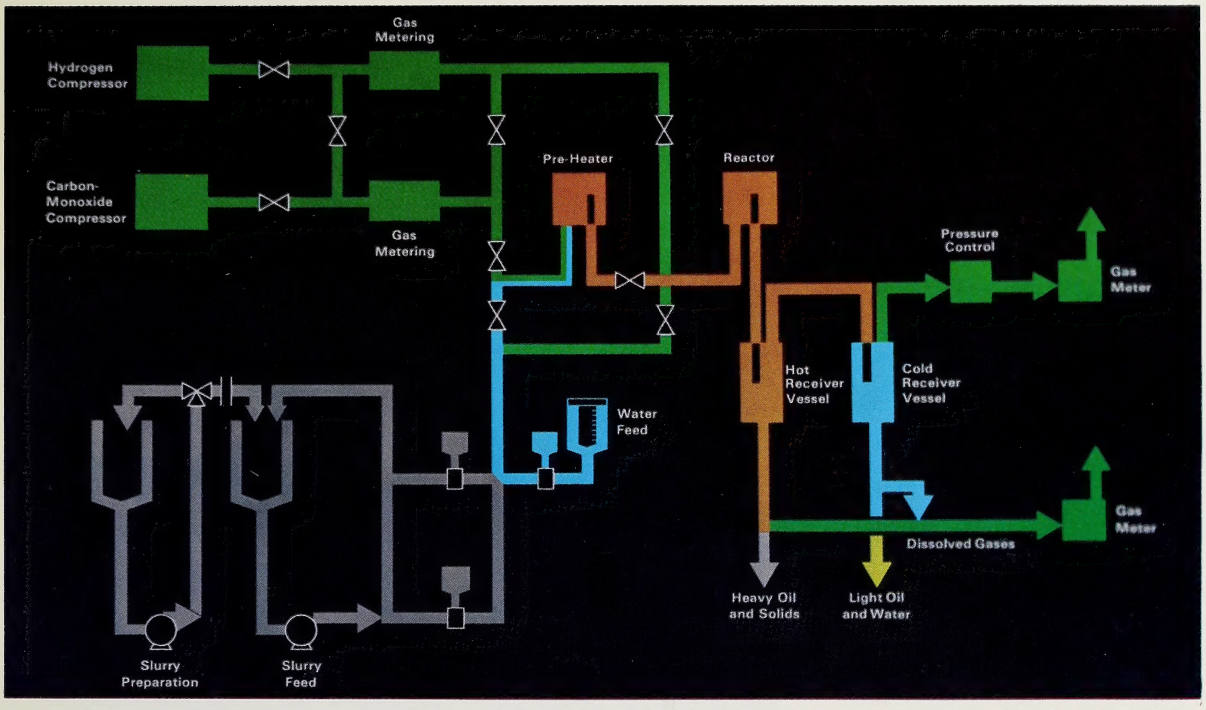
- micro-pyrolyzer system (0.1-1 mg)
- inductively heated screen reactor unit (1-20 mg)
- thermal analysis systems (TGA/DTA/DSC - 10-200 mg)
- atmospheric pressure entrained flow reactor system (1-10 g/hr)
- drop tube gasification/combustion system (3-60 g/hr)
- high pressure PDU (21 MPa; 2 kg/hr)
- down flow combustion system (4 kg/hr)

Variable pressures and different atmospheres during pyrolysis experiments are possible with the bench unit represented by this schematic.

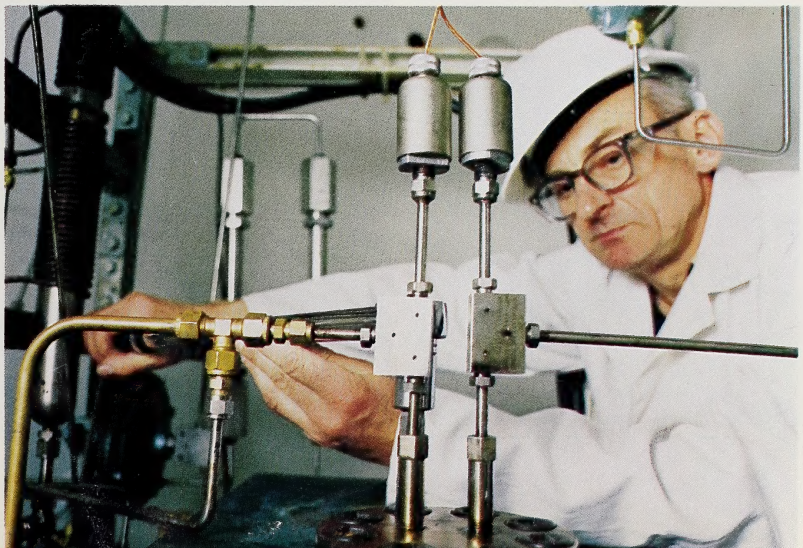


Hydroprocessing research facilities

- batch autoclaves (5 mL - 4 L)
- two-stage hot charge/discharge reactor system (1 and 2 L)
- gas/liquid and gas/slurry catalytic CSTR systems (50-250 mL/hr)
- catalytic PFTR system (5-250 mL/hr)
- PDU dual CSTR system (2-6 L/hr)
- fluidized bed steam cracker (1 L/hr)
- high pressure/temperature viscometer (1 L)



A variety of conditions can be tested in hydroprocessing experiments, using the liquefaction bench unit designed by the Alberta Research Council.



A gradientless catalytic reactor used for hydrocarbon upgrading in catalytic research.

Catalysis research facilities

Reactor systems

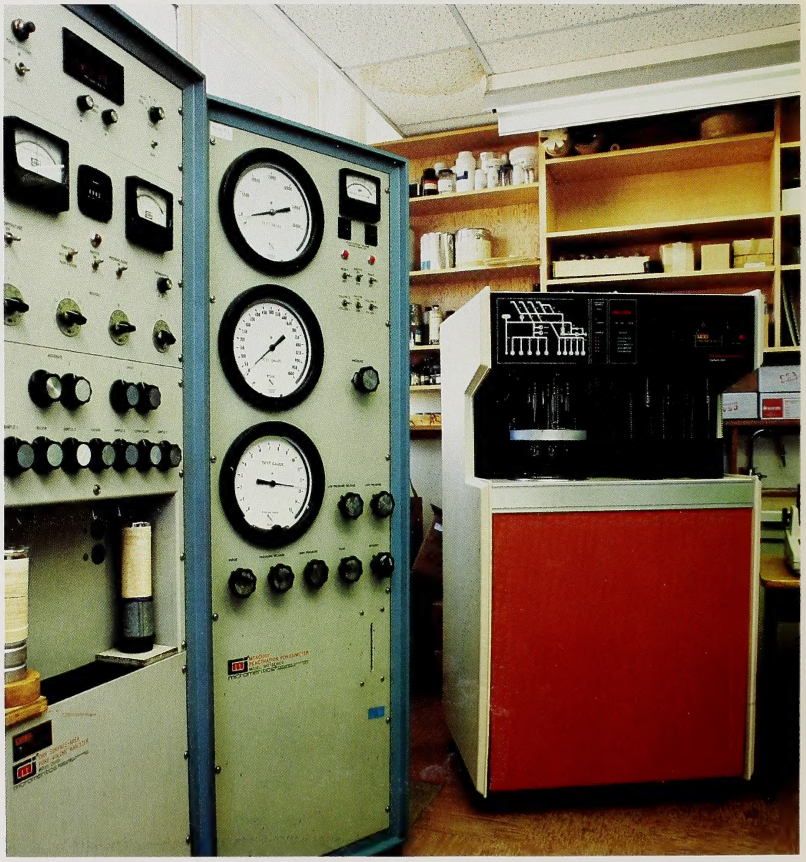
- catalyst test bed continuous flow unit
- tubular flow system for hydrodesulfurization
- Claus reactor
- Berty/Robinson/Carberry reactors
- catalytic reforming reactor

Analytical

- atomic absorption photometer
- argon plasma spectrophotometer (for 36 elements)
- TGA/DTA/DSC
- chemiluminescent detectors (for NO_2, NO, NH_3) ^1H, ^{13}C NMR of liquids and solids

Surface characterization

- particle size analyzer (down to 1 micron)
- helium autopycnometer
- automated BET surface area analyzer
- pore volume/surface area analyzer (chemisorption)
- mercury intrusion porosimeter
- gas/vapor phase adsorption systems
- x-ray fluorescence unit
- automated x-ray diffraction system



A section of the catalyst evaluation center.

Multiple support services

Samples of Alberta coals are stored in a controlled environment.

To back up research projects related to processing of energy resources, the Alberta Research Council has multiple support facilities ranging from sample acquisition and preparation, petrography and analytical services.

The primary function of these facilities is to support the research programs and provide service to private and public sectors for special applications, if similar services are not available from commercial laboratories.

Sample banks
Specimens of coal and oil sands from various Alberta formations are available on request.

Consultation services in sample collection, preparation, storage and transmission are also offered.

Petrography
The Alberta Research Council has petrographic analysis facilities to assist in five recognized areas applied to coal petrography:

- description and classification of coal;
- survey of coal resources;
- blending and preparation of coals for coke making;
- coal preparation;
- coal liquefaction, combustion and gasification.

The Alberta Research Council also has capabilities for complete petrographic characterization of chars and solid liquefied residues by automated reflectance microscopy.

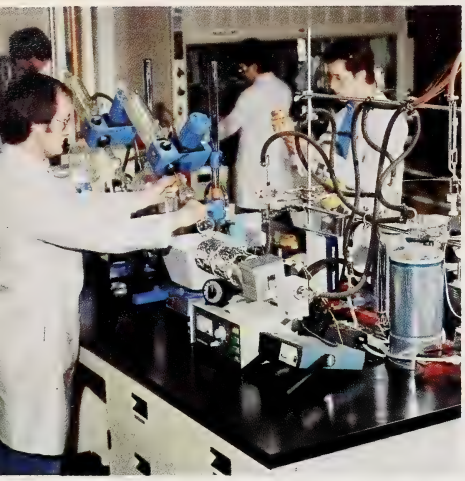
Researchers use petrography for the most advanced methods of studying coal, using white light and fluorescent light.

Engineering services
Engineering services which support various research projects include:

- economic evaluation
- development of data management systems
- computer services
- reactor modeling for process technology
- fuel rating (engine tests)
- project teams to undertake interdisciplinary studies

The characteristics of upgraded products are determined using gas chromatography/mass spectrometry.

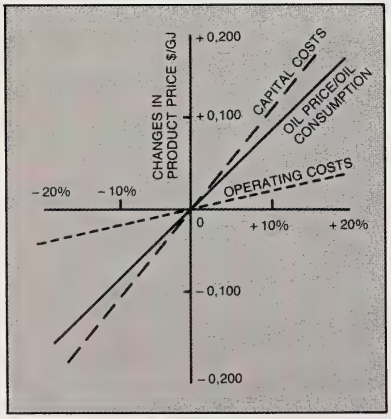
Analytical facilities



Separation and sampling is conducted in preparation for analysis of products from the pilot plant.

Analytical capabilities needed to support research projects provide services for routine and special analyses for gas, liquid and solid fuels. Some of the examples are:

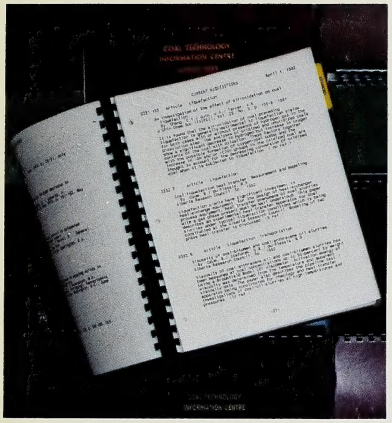
- proximate, elemental analyses (Fisher analyzer, Perkin-Elmer and Leco analyzers for C,H,N, O & S)
- calorific value determination
- gas analysis
- gas chromatography
- trace water analysis
- refractive index, density, viscosity, molecular weight determinations
- thermogravimetric analysis (TGA/DSC)
- class analysis (i.e., determination of oils, resins, asphaltenes, preasphaltenes) by TLC/FID, SARA, column chromatography
- metal and trace metal analysis (AA, x-ray, ICP)
- spectral analyses (UV/VIS, I.R., FTIR, NMR)
- detailed analysis of liquid products using, HPLC, GPC, High Resolution GC, GC/MS, selective detectors
- ^{1}H, ^{13}C NMR of liquids and solids
- surface properties measurements
- *true and particle densities*
- *BET surface area*
- *Porosity*
- *pore volume and size distribution*



Sensitivity Analyses for capital costs, operating costs and oil price — a coal agglomerate case.

A section of the laboratory for product analysis.

Information Centers



Two information centers, related to coal and oil sands technology, specialize in providing the latest information from around the world.

Coal Technology Information Center

The Coal Technology Information Center forms part of the Coal Research Program, jointly funded by the Alberta Research Council and the Alberta/Canada Energy Resources Research Fund administered by Alberta Energy and Natural Resources. It provides the following services:

- COAL-ABS is a computerized, bibliographic database of approximately 13,000 records, which surveys literature throughout the world and is available on-line; it provides information on the various facets of coal conversion (liquefaction and gasification), beneficiation, combustion, environmental aspects and mining technology;
- the Current Acquisitions Bulletin is issued bi-weekly with updates to COAL-ABS;
- the Coal Abstracts Index is a cumulative listing of COAL-ABS cross-referenced by keyword, author and corporate author;
- on-line literature searches and compilation of specialized bibliographies.

Hours of operation:
8:00 a.m. to 12:00 p.m.;
1:00 p.m. to 4:30 p.m.

Contact: Coal Technology
Information Center
Alberta Research Council
1 Oil Patch Drive,
Devon, Alberta
Telephone (403) 987-8111

Alberta Oil Sands Information Centre

The Alberta Oil Sands Information Centre, part of the Oil Sands Research Department, is totally funded by the Alberta Oil Sands Technology and Research Authority. The Centre provided technical information on all aspects of Alberta oil sands, and data on heavy oil and enhanced oil recovery processes.

The following services are provided:

- Alberta Oil Sands Index, updated quarterly, and based on an on-line, computerized database, updated bi-weekly; it is available through SPIRES at the University of Alberta, CAN/OLE at Canada Institute for Scientific and Technical Information in Ottawa, and QL Systems in Calgary;
- Heavy Oil/Enhanced Oil Recovery Index, updated quarterly, and based on an on-line, computerized database, updated bi-weekly; it is available through SPIRES at the University of Alberta and through QL Systems in Calgary;
- Oil Sands Researchers and Projects File, available on-line through SPIRES at the University of Alberta;
- literature searches are conducted for clients, and special bibliographies compiled;
- a newsletter, *TAR Paper,* published every 2 to 3 months.

Hours of operation:
8:00 a.m. to 12:00 p.m.;
1:00 p.m. to 4:30 p.m.

Contact: Alberta Oil Sands
Information Centre
Alberta Research Council
6th Floor, Highfield Place
10010 - 106 Street
Edmonton, Alberta
Canada T5J 3L8

Telephone: (403) 427-8382
Telex: 037 - 2147

Professional personnel

Most professional staff engaged in research related to processing of energy resources have university training at the Ph.D. level. The remainder have M.Sc. or B.Sc. qualifications. The staff has a broad range of expertise and specialization of international recognition level. Engineering and project management skills include economic evaluations.

More information
We welcome enquiries regarding our research capabilities related to processing of energy resources to your specific needs. For additional information contact:

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